A Course Based Project on

PANORAMIC IMAGE STITCHING

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SIGNAL PROCESSING AND COMMUNICATION APPLICATIONS LABORATORY (A19PC2EC10)

BACHELOR OF TECHNOLOGY
in

ELECTRONICS AND COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the course based project entitled "PANORAMIC IMAGE STITCHING" is being submitted by Bonthu Meghana (21071A0407), Burugu Ruthwik (21071A0408), Chelli Vanitha (21071A0409) for the partial fulfillment of requirements for course based project of **Signal Processing and Communication Applications Laboratory** in IV year I semester of Bachelor of Technology in Electronics and Communication Engineering of VNRVJIET, Hyderabad during the academic year 2024 – 2025.

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DECLARATION

We do declare that the course based project report entitled " PANORAMIC IMAGE STITCHING" submitted to the Department of Electronics and Communication Engineering, Vallurupalli Nageswara Rao Vignana Jyothi Institute of Engineering and Technology, Hyderabad, in partial fulfillment of the requirements for course based project of Signal Processing and Communication Applications Laboratory in IV B.Tech. I Semester for the academic year 2024 - 2025.

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ABSTRACT

Panoramic image stitching is a fundamental technique in computer vision used to generate wide-field-of-view images by combining multiple overlapping photos. This project leverages **feature-based stitching**, employing methods such as feature detection, matching, and geometric transformation to align and merge images seamlessly.

Using MATLAB's Image Processing Toolbox, the process involves detecting robust features (e.g., SURF), estimating projective transformations, and blending aligned images to form a coherent panorama. The methodology demonstrates robustness in scenarios with varying lighting conditions and image overlaps, providing insights into the optimization of stitching workflows for real-world applications.

INDEX

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 Introduction:

Panoramic stitching is widely used in photography, cartography, and augmented reality to generate expansive views from multiple images. This process involves aligning overlapping regions between images and blending them into a unified output. Feature-based methods, as implemented in this project, leverage advanced algorithms for keypoint detection and geometric transformation, offering high reliability. MATLAB's Computer Vision Toolbox is used to facilitate the process, ensuring efficient computation and ease of implementation. The procedure for image stitching is an extension of feature based image registration. Instead of registering a single pair of images, multiple image pairs are successively registered relative to each other to form a panorama.

This project delves into the field of panoramic image stitching, an integral aspect of computer vision that seamlessly merges multiple overlapping images into a wide-angle panorama. It focuses on implementing a feature-based approach to achieve high precision and scalability in stitching.

The process involves detecting distinct features, matching corresponding points, estimating transformations, and blending images into a coherent output. Advanced algorithms such as SURF for feature detection and RANSAC for robust transformation estimation ensure accurate alignment, even in scenarios with noise or distortions.

Panoramic image stitching has vast applications across diverse fields such as photography, mapping, surveillance, and virtual reality. By creating expansive visual representations, it offers enhanced perspectives and improved context. This project aims to deliver an efficient and reliable solution, highlighting the effectiveness of feature-based methods in real-world applications.

CHAPTER 2: WORKING PRINCIPLE

The panoramic image stitching process involves multiple steps, utilizing advanced techniques to ensure precision and seamless results.

1. Feature Detection

The **SURF (Speeded-Up Robust Features)** algorithm is employed to detect distinct key points in input images. These key points represent unique image regions (e.g., corners, blobs) that are highly identifiable across scales and rotations. SURF efficiently computes feature descriptors, compact vectors that encode the local structure around each key point. This ensures robustness against changes in scale, rotation, or lighting conditions.

2. Feature Matching

Key point descriptors from overlapping images are compared to find correspondences. A common metric, such as the Euclidean distance, measures the similarity between descriptors, establishing a map of matched points. To enhance accuracy, mismatched or outlier points are identified and excluded during subsequent steps.

3. Transformation Calculation

Using the matched key points, a geometric transformation model is estimated. **RANSAC (Random Sample Consensus)** is applied to identify the best-fitting transformation while excluding outliers. This iterative process ensures robustness, even in the presence of noise or incorrect matches. Transformations like affine or projective models are computed depending on the alignment requirements.

4. Image Warping

The calculated transformation is applied to warp the images. This process aligns overlapping images into a shared coordinate system while preserving their geometric relationships. The warping step ensures proper alignment and prepares the images for seamless blending.

5. Image Blending

Aligned images are merged using blending techniques to smooth transitions and minimize visual artifacts. Common methods include linear blending and multi-band blending, which balance the intensity differences at image boundaries. This step ensures that the final output appears seamless and visually cohesive.

By leveraging robust techniques like SURF for key point detection and RANSAC for transformation estimation, this methodology achieves accurate and efficient panoramic stitching. The resulting panorama is both visually appealing and adaptable to real-world scenarios.

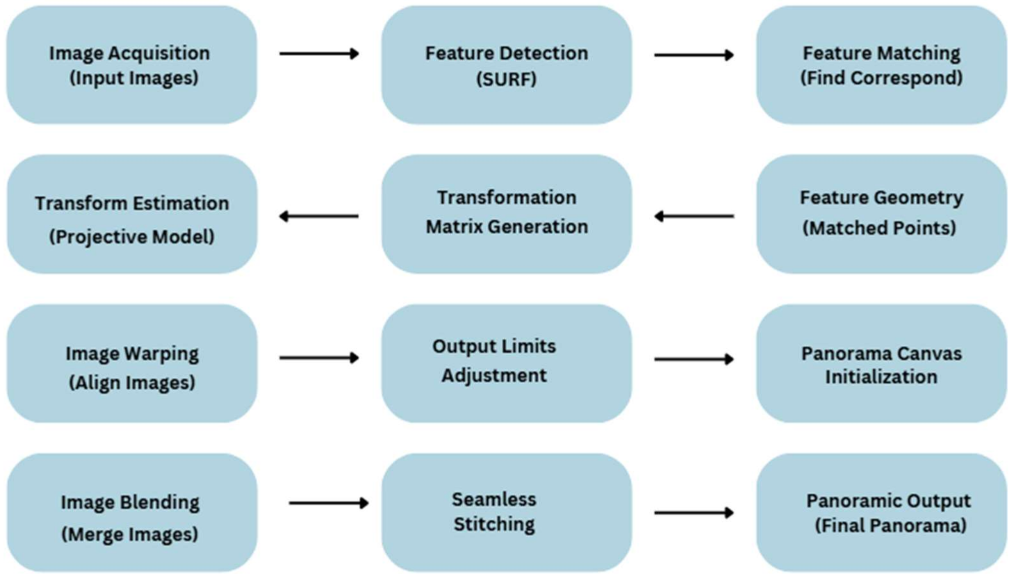

Fig2.1.a. Block Diagram for Panoramic Image Stitching

CHAPTER 3: CODING

```
% Loading images
buildingDir = fullfile(toolboxdir("vision"), "visiondata", "building");
buildingScene = imageDatastore(buildingDir);

% Display images as a montage
montage(buildingScene.Files);

% Register Image Pairs
I = readimage(buildingScene, 1);
grayImage = im2gray(I);
points = detectSURFFeatures(grayImage);
[features, points] = extractFeatures(grayImage, points);

% Initialize transformations to identity matrix
numImages = numel(buildingScene.Files);
tforms(numImages) = projtform2d;
imageSize = zeros(numImages, 2);

% Iterate over the remaining images to register them
for n = 2:numImages
    pointsPrevious = points;
    featuresPrevious = features;

    I = readimage(buildingScene, n);
    grayImage = im2gray(I);
    imageSize(n, :) = size(grayImage);

    points = detectSURFFeatures(grayImage);
    [features, points] = extractFeatures(grayImage, points);

    indexPairs = matchFeatures(features, featuresPrevious, 'Unique', true);
    matchedPoints = points(indexPairs(:, 1), :);
    matchedPointsPrev = pointsPrevious(indexPairs(:, 2), :);

    tforms(n) = estgeotform2d(matchedPoints, matchedPointsPrev, 'projective', 'Confidence',
99.9, 'MaxNumTrials', 2000);

    % Update the transformation to be relative to the first image
    tforms(n).A = tforms(n-1).A * tforms(n).A;
end
% Adjust transformations for aesthetic quality
% Compute the output limits for each transformation
for idx = 1:numel(tforms)
    [xlim(idx,:), ylim(idx,:)] = outputLimits(tforms(idx), [1 imageSize(idx, 2)], [1
imageSize(idx, 1)]);
end

% Find the center image based on the average X limits
avgXLim = mean(xlim, 2);
[~, idx] = sort(avgXLim);


centerIdx = floor((numel(tforms)+1) / 2);
centerImageIdx = idx(centerIdx);

% Invert the center image's transformation and apply to all images
Tinv = invert(tforms(centerImageIdx));
for idx = 1:numel(tforms)
    tforms(idx).A = Tinv.A * tforms(idx).A;
end
```

```
% Initialize the Panorama Canvas
for idx = 1:numel(tforms)
    [xlim(idx,:), ylim(idx,:)] = outputLimits(tforms(idx), [1 imageSize(idx, 2)], [1
imageSize(idx, 1)]);
end

maxImageSize = max(imageSize);

xMin = min([1; xlim(:)]);
xMax = max([maxImageSize(2); xlim(:)]);
yMin = min([1; ylim(:)]);
yMax = max([maxImageSize(1); ylim(:)]);

width  = round(xMax - xMin);
height = round(yMax - yMin);

% Initialize the panorama with a blank canvas
panorama = zeros([height width 3], "like", I);

% Create 2-D spatial reference for the panorama
xLimits = [xMin xMax];
yLimits = [yMin yMax];
panoramaView = imref2d([height width], xLimits, yLimits);

% Warp and blend each image into the panorama
for idx = 1:numImages
    I = readimage(buildingScene, idx);
    warpedImage = imwarp(I, tforms(idx), 'OutputView', panoramaView);
    mask = imwarp(true(size(I, 1), size(I, 2)), tforms(idx), 'OutputView', panoramaView);
    panorama = imblend(warpedImage, panorama, mask, 'ForegroundOpacity', 1);
end

% Display the final panorama
figure;
imshow(panorama);
title('Final Panorama')
```

CHAPTER 4: RESULTS

4.1 Results:

Fig.4.1.a.Image Set of buildings

The figure 4.1.a comprises six images, the original images set of buildings, These were taken with an uncalibrated smart phone camera by sweeping the camera from left to right along the horizon, capturing all parts of the building. The images are relatively unaffected by any lens distortion so camera calibration was not required. The figure 4.1.b is the final panorama by warping each image.

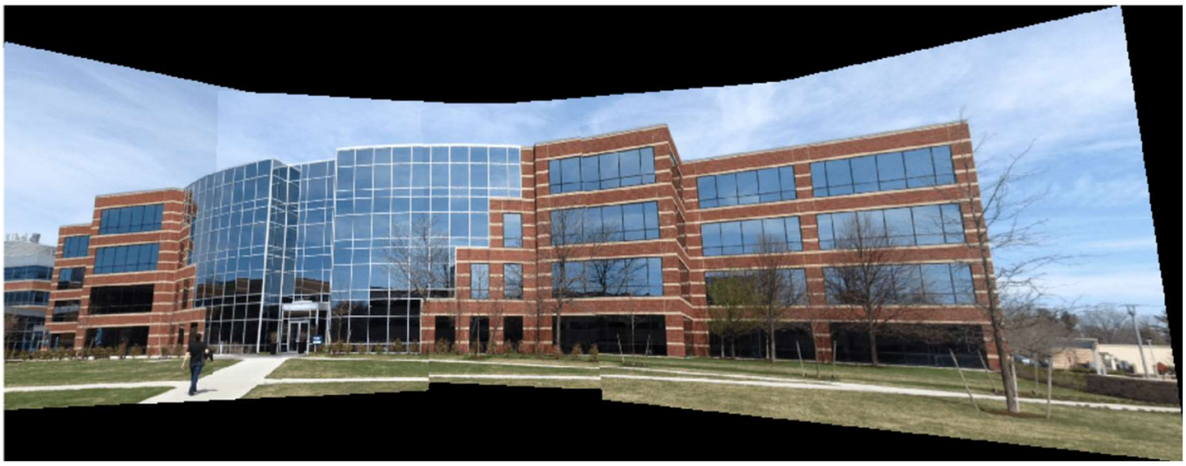

Fig.4.1.b Final Panorama

CHAPTER 5: CONCLUSION

In conclusion, the project ″Feature-Based Panoramic Image Stitching″ successfully demonstrates the creation of seamless panoramic images using advanced feature-based methods. By employing the SURF algorithm for feature detection and matching, and leveraging projective transformations for image alignment, the implemented approach proved to be robust and effective in handling a variety of overlapping image sets.

The final panoramic output showcases the integration of multiple images into a single cohesive view, minimizing distortions and blending artifacts. This methodology can be extended to real-world applications such as virtual tours, aerial mapping, and advanced photography.

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